MASTER OF SCIENCE
IN
MECHANICAL ENGINEERING

AN APPROACH FOR IMPRESSION CREEP
OF LEAD FREE MICROELECTRONIC SOLDERS
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This thesis examines impression creep tests of eutectic Sn-Ag. A testing program and apparatus was developed and constructed based on a servo hydraulic test frame. The apparatus is capable of a load resolution of 0.01N with a stability of ±0.1N, and a displacement resolution of 0.05μm with a stability of ±0.1μm. Samples of eutectic Sn-Ag solder were reflowed to develop the microstructure used in microelectronic packaging. Creep tests were conducted at various stresses and temperatures and showed that coarse microstructures creep more rapidly than fine microstructures in the tested regime.

KEYWORDS: Impression Creep, Lead Free Solder

IMPROVED AEROTHERMODYNAMIC INSTRUMENTATION OF AN ALLISON T63-A-700
GAS TURBINE ENGINE
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This document describes the design, installation, and operation of an improved measurement system for the aerothermodynamic flow path states in an Allison T63-A-700 (C250-18 civilian designation). Temperature measurements for the gas generator turbine and exhaust state points were evaluated and average values were calculated. The measurement uncertainty for airflow, fuel flow, and output power has been reduced to less than 3%. State points match installation design data within 3%. The digital scanning array has improved the accuracy of the pressure measurements and added the ability to measure pressure differences over time. The added bellmouth pressure sensors provide a redundant pressure measurement that is more accurate than the dynamometer system. The gas generator turbine inlet and exhaust temperature profiles have been measured and show that the temperature profile becomes less symmetrical with increasing air and fuel flow. The measurement values for the gas generator inlet temperature have been consolidated into a single value that is about 50 degrees different from expected values. The temperature profile at the power turbine inlet shows how the hot spot at the gas generator turbine inlet is affected by the swirl produced by the power turbine stages. The time resolved fluctuations in pressure between the compressor and gas generator turbine have been measured and show that compressor discharge and gas generator turbine inlet pressures are similar.

KEYWORDS: aerothermodynamic instrumentation, gas turbine engine, gas generator turbine inlet

EXPERIMENTAL STUDIES OF NOISE/VIBRATION DAMPING FOR UNDERSEA WARFARE APPLICATIONS

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Maintaining silence underwater is an important issue with undersea warfare. One technique to reduce noise radiation is to use a passive noise/vibration material. The objective of this research was to investigate the vibration properties of an aluminum foam with various types of damping treatment. The importance of the determination of the damping properties of the aluminum foam and various damping treatments was for the future development of materials that would reduce the radiated noise of undersea weapons and onboard machinery. The frequency response was determined using three tests; swept sine, impact hammer, and random noise. The natural frequencies were determined by examining the Nyquist plot of the frequency response. The damping ratios were determined by using the half-power point method.

KEYWORDS: Vibration, Damping, Constrained Viscoelastic Layer, Viscoelastic Damping, Noise

DYNAMIC ANALYSIS OF A ROTATING DISK WITH A TIME-VARYING ASYMMETRIC MASS DISTRIBUTION

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The objective of this thesis and research was to investigate the dynamic analysis of a rotating disk, with a time-varying asymmetric mass distribution, in two ways. The redistribution of mass was achieved by flipping the disk intermittently, and by moving a mass carried on the disk. The actual system is comprised of either two or four disks. The system was simulated using *Working Model 3D*, and mathematical calculations were performed for disk motion, forces, and moments in *Mathematics* and *MATLAB*.

KEYWORDS: Dynamic Analysis, Rotating Eccentric Mass, Asymmetric Mass

COMPUTATIONAL DYNAMICS AND STRESS ANALYSIS OF FULL-SCALE MODEL ROLL-ON, ROLL-OFF (RORO) STERN RAMP WITH WAVE MOTION COMPENSATION

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The current design of the stern ramps used in roll-on, roll-off (RORO) operations, proved to be structurally inadequate for use during Sea State Three. Therefore, a motion compensator is considered for use between the stern ramp and the RORO discharge facility (RRDF). This motion compensator's purpose is to mitigate torsion in the ramp, reducing the stress level. This thesis documents a thorough investigation of the performance and behavior of two different motion compensation devices conceived by two separate vendors. This thesis provides the documentation of the development of the finite element models and the impact the compensator models have in stress levels when integrated with the stern ramp models. Critical loading conditions are also evaluated in the stern ramps, both with and without compensators.

KEYWORDS: Roll-on Roll-off, Stern Ramp, Motion Compensation, Wave Action, Torsion, Stress Analysis, Cape T, Cape H, LMSR

TRAJECTORY PLANNING FOR THE *ARIES* AUV
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This thesis supports ongoing ONR research in the area of Autonomous Underwater Vehicles (AUVs) and Mine Warfare. It shows a simulation of a two-vehicle autonomous rendezvous using both along track and cross track position controllers. Conducting open water experiments with the *ARIES* AUV identified the added mass matrix and hydrodynamic coefficients of the longitudinal equation of motion. The results indicate that it will be possible to maneuver an AUV to a specific rendezvous point at a specified time. Two-vehicle rendezvous maneuvers are likely to be needed in multi-vehicle operations when data transfer between range-limited communications modems are used.

KEYWORDS: Underwater Vehicle, AUV, Trajectory Planning, Control

ANALYSIS OF THE APPLICABILITY OF AIRCRAFT VULNERABILITY ASSESSMENT AND REDUCTION TECHNIQUES TO SMALL SURFACE CRAFT
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The concepts of vulnerability assessment and reduction have long been employed in the design of military aircraft. Aircraft design has many similarities to the design of small surface craft. Both disciplines deal with minimal recoverability and limited space, space that is crucial for critical component redundancy, separation, and many other principles of vulnerability reduction. This report attempts to directly apply established aircraft vulnerability assessment and reduction techniques to small surface craft, in particular, the *Cyclone*-class Patrol Coastal craft.

KEYWORDS: Small Craft, Survivability, Vulnerability, Patrol Craft, Vulnerability Assessment, Vulnerability Reduction

ANALYSIS OF TURBULENCE MODELS IN A CROSS FLOW PIN FIN MICRO-HEAT EXCHANGER
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In this study, several turbulence models are analyzed in a 3D finite element model of a micro-heat exchanger. The micro-heat exchanger consists of a narrow planar flow passage between parallel walls with small cylindrical pin fins spanning these walls with axes perpendicular to the direction of flow. Turbulence model performance is compared with baseline experimental data available in the literature which cover a range of Reynolds numbers and spacing configurations. The metric for these comparisons is an array averaged Nusselt Number. Adjustments made to the coefficients in the turbulence models are explained in terms of their physical significance to the complex flow environment of a pin fin, cross flow, micro-heat exchanger. Applications for this research include turbine blade cooling and closely spaced electronics cooling.

KEYWORDS: Pin-Fin Array, Compact Heat Exchanger, Heat Transfer, Micro Heat Exchanger, Turbine Blade Cooling

LOITERING BEHAVIORS OF AUTONOMOUS UNDERWATER VEHICLES

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In multi-vehicle mine hunting operations, it will be necessary at times for one vehicle to loiter at some point while gathering communications of data from other vehicles. The loitering behaviors of the *ARIES* Autonomous Underwater Vehicle have never been completely defined. The track that the vehicle chooses to maintain station while circling around one specific point for an extended period of time may be sometimes random and unpredictable, unless defined in terms of specific tracks. Simulations were run and analyzed for various conditions to record the tendencies of the vehicle during different current conditions and approach situations. The stability of the Heading Controller was then analyzed in order to predict the position where the Line-of-Sight Guidance algorithm becomes unstable. The data obtained through the simulations supports and explains the tendencies *ARIES* exhibits while circling around a loiter point.

KEYWORDS: Autonomous Underwater Vehicles, Robotics, Loitering Behavior, Line-of-Sight Guidance Instability, Liapunov Stability/Instability Theorem